NATIONAL STONE, SAND & GRAVEL ASSOCIATION

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NSSGA
MINERAL IDENTIFICATION AND MANAGEMENT GUIDE

INTRODUCTION

This **Mineral Identification and Management Guide ("Identification Guide")** provides a range of investigatory tools with which to assess whether protocol mineral fibers are present on a quarry site. In certain regions of the United States, including areas where Rock Co. operates in the construction materials business, igneous and/or metamorphic rocks are quarried for aggregate. This includes operations where sand and gravel deposits, derived primarily from such igneous or metamorphic parent materials, are being mined.

Some igneous and metamorphic rock materials have the potential to contain, as minor constituents, asbestiform minerals. Six of these asbestiform minerals are currently regulated as asbestos by the US EPA, MSHA, and OSHA because of their proven health risks. Rock Co.'s Identification Guide goes beyond these six minerals and includes additional asbestiform minerals it has elected to treat as equivalent in risk. The mineralogical properties of asbestos and a list of the regulated mineral fibers and the additional asbestiform minerals covered by this Identification Guide (hereinafter referred to as "protocol mineral fibers") are outlined below.

This Identification Guide applies to designated Rock Co. mining sites where there is a potential that protocol mineral fibers may exist. It is designed to determine:

- The presence or absence of asbestiform minerals in the rock materials
- The mineralogy of any asbestiform material, to ascertain the health and regulatory impact
- The quantity and distribution of any protocol mineral fibers
- Based on the foregoing analysis, what steps, if any, Rock Co. should take, which may include modification in the area of the property where mining occurs and/or implementation of air sampling, increased settled dust sampling, employee training, product sampling, or a visual identification plan, etc.

For greenfield sites, the Identification Guide begins with an evaluation of whether there is the potential for protocol mineral fibers to be present. This program for greenfield sites is outlined in the **Section 3*, Qualitative Geologic Survey***.

The goal of the program outlined in the Identification Guide is to identify and manage potential areas where protocol mineral fibers occur in order to avoid producing aggregate materials which release such protocol mineral fibers in excess of federal, state, or local limits related to asbestos exposure, including Permissible Exposure Limits established by the Occupational Safety and Health Administration and Recommended Exposure Limits established

by the Mine Safety and Health Administration. The program outlined in the Identification Guide is intended to be tailored by geologic personnel or consultants such that it is appropriate for the geologic and production realities of a particular site.

Asbestos and Protocol Mineral Fibers

Asbestos is a commercial term that describes a variety of certain silicate minerals, belonging to the serpentine and amphibole mineral groups, which have crystallized in the asbestiform texture (i.e., crystallizes with the habit of asbestos). This causes them to be present in bundles that are easily separated into long, thin, flexible, strong fibers when crushed or processed.

According to the National Institute of Standards and Technology (NIST), Certificate of Analysis, Standard Reference Material® 1867a, Uncommon Commercial Asbestos, "asbestos minerals possess (certain) properties such as long fiber length and high tensile strength. Under the light microscope . . . samples exhibit the asbestiform habit as defined by several of the following characteristics: 1) mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 μm, 2) very thin fibrils, usually less than 0.5 μm in width, 3) parallel fibers occurring in bundles, 4) fiber bundles displaying splayed ends, 5) fibers in the form of thin needles, 6) matted masses of individual fibers, and 7) fibers showing curvature."

Each of the protocol minerals exists more commonly in a prismatic crystal growth habit or form (i.e., a non-asbestiform habit or form). These non-asbestiform minerals tend not to grow with parallel alignment, but instead form multi-directional growth patterns. When pressure is applied, the crystals fracture easily, fragmenting into prismatic particles called cleavage fragments. While some cleavage fragments are acicular or needle-shaped as a result of the tendency to cleave along two dimensions but not along a third, they do not possess the characteristics described above for asbestiform minerals. Furthermore, these cleavage fragments are not associated with asbestos-related diseases as documented in the published, peer-reviewed scientific literature.

The United States EPA, MSHA, and OSHA regulate as asbestos the asbestiform habit of ***chrysotile***, a member of the serpentine mineral group; and the asbestiform varieties of certain amphiboles: ***actinolite, crocidolite***, ***amosite***, ***anthophyllite***, and ***tremolite***.

In addition to the general class of asbestiform amphiboles, Rock Co.'s Identification Guide includes ***all asbestiform amphiboles*** and ***all durable asbestiform zeolites*** in Rock Co.'s protocol mineral fiber definition. Durable asbestiform zeolites include, but are not limited to, erionite and mordenite.

Application of the Mineral Identification Guide

The **Mineral Identification Guide** applies to both new and existing sites, and is implemented in four steps:

- **Step #1. Periodic on-site geologic inspections**. Annually, or at such periods established by geology staff, at each of the quarries and sand and gravel pits that are subject to the Identification Guide, an inspection for the possible presence of protocol mineral fibers by the geology staff or its consultants should be conducted.

  Additionally, Rock Co. expects all of its miners, geologists, and other employees who work at our sites to immediately report any suspected protocol mineral fibers that are discovered to the quarry management, such that further investigation may be conducted. **See Section 1**, ***Periodic Inspection Program.***

- **Step #2. Program for Testing Settled Dust**. For mining sites which are subject to this Identification Guide, the ***Program for Testing Settled Dust*** is generally conducted on an ongoing basis, with settled dust samples collected by the geology staff (or consultants with geologic training) as appropriate. **See Section 2, *Program for Testing Settled Dust.***

- **Step #3. Qualitative Geologic Survey**. There are various situations that may lead to the discovery of protocol mineral fibers. Protocol mineral fibers may be discovered as described in Step #1 above during periodic inspections by geology staff or may be found at a mining site during normal operations, as a result of drilling or other geologic or mining activity. Protocol mineral fibers may be discovered in the settled dust samples from a mining site in Step #2 above. A governmental agency may identify a mining site as potentially having protocol mineral fibers.

  In any of these situations where protocol mineral fibers have been found, Rock Co.'s program then provides for a ***Qualitative Geologic Survey***. The purpose of this survey is to locate the source of and define the distribution of the protocol mineral fibers by a detailed field assessment conducted by geology staff (or consultants with geology training). This evaluation includes a literature survey and field assessment, with dust samples and suspect rock samples collected for evaluation. **See Section 3, *Qualitative Geologic Survey*.**

- **Step #4. Further Steps**. If the Qualitative Geologic Survey, in conjunction with a comprehensive mine plan, shows that protocol mineral fibers may occur at a site, determine what steps, if any, Rock Co. should take, which may include modification in the area of the property where mining occurs, and/or implementation of air sampling, increased settled dust sampling, employee training, product sampling or a visual identification plan, etc.

SECTION INDEX

Section 1
Periodic Inspection Program

A key component to this Identification Guide is the implementation of this ***Periodic Inspection Program***. Field examination by a trained geologist can identify certain localities that are suspect for the presence of protocol mineral fibers. The field geologist may be either an employee or a consultant retained to advise management.

Annually or at such periods established by geology staff, at each of the quarries and sand and gravel pits that are subject to the Identification Guide, geology staff should inspect all walls and benches that are safely accessible at each of these sites to determine if there is any indication of the presence of protocol mineral fibers. After the initial field evaluation, any future periodic inspections will concentrate only on the active walls and benches in any given site. Suspect locations may be properly documented (easting, northing, elevation), photographed, and samples appropriately evaluated through microscopic procedures. Additionally, Rock Co. expects all of its miners, geologists, and other employees who work at our sites to immediately report any suspected protocol mineral fibers that are discovered to the quarry management, such that further investigation may be conducted.

In some cases identification of protocol mineral fibers is obvious in the field. In other cases, only the type of rock mass or the relationship to joints, shear zones, or intrusions are indicative of potential suspect areas for the presence of protocol mineral fibers. Careful sampling and microscopic evaluation of these areas is necessary to determine the presence or absence of these minerals. In some cases further study by electron microscopy may be warranted. Personnel or consultants with a background in geology should determine the proper course of action for field evaluation and identification, sampling, and examination of the samples at their respective sites.

Section 2
Program for Testing Settled Dust

A program for testing settled dust is to be conducted at all Rock Co. quarries where igneous and/or metamorphic rocks are being mined. Additionally, Rock Co. quarries in limestone or dolomite which have been altered by metamorphism or by igneous intrusion are also subject to this program. Selected sand and gravel operations may also be subject to this program; particularly where the source for the sand and gravel deposits is from a geologic terrain with rock that is known to contain protocol mineral fibers.

Recommended process:

1. A specific coordinator for this ***Program for Testing Settled Dust*** is recommended. Typically, this person has an environmental health or safety background. This person may also be involved in other technical activities such as quality control or geology. This role may also be filled by a consultant with appropriate training.

2. The coordinator is responsible for ensuring that settled dust samples are properly collected, individually sealed, and properly identified at all participating quarries and/or sand and gravel operations as appropriate under the schedule established by Rock Co.

3. A goal of this Program is to collect samples which reflect the complete production of a site. The appropriate amount of sampling may vary depending on site conditions and the amount of mining conducted at a particular site. Experience would show that quarterly sampling is generally recommended, but this frequency of sampling may not be appropriate for all production volumes and site conditions.

4. A suggested procedure for collecting settled dust is as follows:

    a. A minimum of two settled dust samples will be collected at each participating quarry and/or sand and gravel operation.

    b. The sampling containers should be of similar size to a wide-mouthed Nalgene® jar, approximately 4 ¾ inches in diameter and 1 ¾ inches deep. A container of these dimensions will provide adequate surface area for a settled dust sample to be properly collected.

    c. Samples are to be collected simultaneously during the test period, individually sealed, and properly identified by site. Site identification may include: the name of the quarry or sand and gravel operation sampled, the location sampled, the dates of the sample period, and the name of the sample collector.

    d. Sampling sites must be in an area away from thrown rock particles, wind, and precipitation; i.e., in a protected location that will allow for the effective accumulation and preservation of a settled dust sample.

e. A properly collected settled dust sample will have the consistency of flour or talcum powder. The samples should not be gritty, sandy, or contain obvious large rock chips. The sample should not be more than one handful of material. Large sample quantities or those containing larger sized rock material may suggest that the sample site is not appropriate or that the sample has been "scooped up" rather than settled from the airborne dust over the time period of interest. If samples appear to be improperly collected, the coordinator must work with location management to ensure that samples are correctly gathered in the future. This may mean repositioning the sample collection site.

5. The sample may be tested pursuant to the EPA test method entitled "Method for the Determination of Asbestos in Bulk Building Materials" (EPA/600/R-93/116), or under an equivalent method.

6. This settled dust program and these dust samples are not to be commingled with any other studies or samples intended strictly for rock quality or customer purposes.

7. If there is a positive determination of protocol mineral fibers, Rock Co. should move forward to subsequent steps in this process, i.e. the ***Qualitative Geologic Survey***.

Section 3
Qualitative Geologic Survey

Rock Co. should conduct a ***Qualitative Geologic Survey*** at our operating mining sites under any of the following conditions:

1. Protocol mineral fibers are confirmed as a result of on-site inspections by the geology staff;

2. Protocol mineral fibers are confirmed in the settled dust samples from a site as a result of our ongoing Settled Dust Program;

3. Protocol mineral fibers are confirmed at a site during normal operations, as a result of drilling or other geologic or mining activity; or

4. A governmental agency determines that protocol mineral fibers may be present at a site.

Additionally, a geologic survey with respect to protocol mineral fibers may be conducted when:

1. Expansion of operations at an existing Rock Co. mining site which is subject to this Identification Guide including adding new mining acreage which has not yet been effectively evaluated for the potential of protocol mineral fibers, a major plant reconstruction, or reactivating an old site which has never been evaluated for protocol mineral fibers;

2. Development of an existing Rock Co. greenfield site subject to this Identification Guide as a mining site.

The ***Qualitative Geologic Survey*** for protocol mineral fibers is separate from and in addition to any other geologic assessment being done to evaluate overburden and weathered rock issues, the quality and quantity of reserves, and any other issues such as groundwater and rock mechanics.

A. Qualitative Geologic Survey for Plant Expansions and Greenfield Site Development

The preliminary geologic evaluation may conclusively show that:

a) the rock material involved is not a metamorphic rock and not an igneous rock; and

b) the rock material is a sedimentary rock or an unconsolidated sediment which is likely **not suspect**.

Materials are likely **not suspect** when the mineral components and/or depositional history indicate that no amphibole, durable zeolite, or serpentine mineral constituents exist; e.g., a carbonate rock which is not metamorphosed or intruded by igneous materials or a sand and gravel deposit which is not derived from a geologic source terrain with rock known to contain protocol mineral fibers. If the results of the preliminary evaluation show that protocol mineral fibers are likely **not suspect**, the evaluation is completed. Geology staff (or consultants with geology training) may document such findings in the manner typically contemplated under Rock Co. operating procedures.

In contrast, rock material is possibly **suspect** when it is a metamorphic rock or igneous rock, and/or when mineral components and/or depositional history indicates that amphibole, durable zeolite, or serpentine mineral constituents exist. When protocol mineral fibers are **suspect**, a ***Qualitative Geologic Survey*** may be conducted.

B. Qualitative Geologic Survey for Existing Sites

The purpose of the ***Qualitative Geologic Survey*** is to define the distribution of any protocol mineral fibers by a detailed field assessment conducted by personnel or consultants who are trained geologists.

The recommended process for the Qualitative Geologic Survey includes:

1. It is good practice to assign a **site identification number** for future reference relative to mineral identification. The site identification number is assigned simply so that a proper paper trail can be maintained when sending samples out to private laboratories for further analysis without identifying a site by its actual name or location.

2. Conduct a comprehensive literature survey, specific to the area of the site, to develop data to serve as a basis for a field assessment and for a structural and/or mineralogical interpretation. This survey may generally include but not be limited to accessing public databases, including those of the USGS, the State Geologic Survey, and local universities and colleges having relevant records. While no specific references may be available regarding the presence or absence of protocol mineral fibers, data regarding rock types and distribution, geologic structure and history will be useful to complete the holistic assessment envisioned herein.

3. Unless an adequate geologic evaluation plan already exists, conduct a geologic evaluation plan to serve as a guide for determining rock types and their distribution, the association of any protocol mineral fibers with the various rock types, and an estimate of the relative quantities of each.

4. Unless an adequate field survey exists, conduct a field survey, consisting of the geologic mapping of rock types / distribution of materials in the walls and benches of the quarry or pit and include available core and outcrop data. The resulting geologic map of the total mining property will be to scale on an appropriate aerial or

topographic base and will document locations/elevations of available drilling and outcrops.

5. Unless adequate rock samples have already been collected, collect representative samples of rock materials in areas most likely to contain protocol mineral fibers. This will include any available core samples. Sample locations/elevations may be documented on a geologic map as discussed above. Additionally, dust and finely ground materials that have accumulated on beams, in surge tunnels, and under crushers or screening towers should be sampled for examination. These samples will be examined for protocol mineral fibers and representative samples as outlined in **Appendix A,** ***Identification of Protocol Mineral Fibers***. The results of this analysis should be included in the geologic report of the site.

6. Document data and information collected from this survey, including geologic maps and cross-sections noting the presence or absence of protocol mineral fibers at the sample locations and potential quantities of protocol mineral fibers as estimated from laboratory analyses extrapolated by rock type through the reserve.

7. It may be appropriate to conduct additional drilling and sampling if it is determined from mapping at the site that there is inadequate drilling, sampling, and testing to properly define the extent of the potential presence of protocol mineral fibers, or if it is necessary to address specific targeted areas where the geologic information points to the presence of protocol mineral fibers.

8. If as a result of this investigation protocol mineral fibers are found, then Rock Co. should develop recommendations for future mining which take into account the results of the ***Qualitative Geologic Survey***. At this point, this ***Qualitative Geologic Survey*** shall be deemed completed. Based on the mine plan, such recommendations may include moving the location of the mining, a visual inspection plan, increased settled dust sampling, air monitoring, employee training and/or a product sampling protocol, etc.

9. Importantly, it is not possible to generically define how much drilling, sampling, and testing may generally be done to satisfy this protocol at every site. All of this will be governed by the complexity of the geology of any specific site. Nor is it possible to specifically define the level of detail necessary for the geologic report. The intent of this process is to develop a concise, executive summary type report, especially if no protocol mineral fibers are found. Such a report will reflect the course of action determined by Rock Co.

Appendix A
Identification of Protocol Mineral Fibers

Basic microscopic analysis of all samples as prescribed by this Identification Guide using Polarized Light Microscopy (PLM) techniques should be performed under the following parameters:

- This analysis will be conducted by a geologist who has earned at least a BS and MS degrees in geology and with specific education and/or training in optical mineralogy techniques.

- Prior to PLM analysis, the geologist will inspect hand and core samples under the Binocular Microscope, ranging from 10x to 60x magnification. Using a fine steel pick (dental pick) the geologist will scrape the surface of the suspect mineralization to determine if any of the minerals display typical asbestiform habit and characteristics such as fiber bundles, splayed ends, or matted or fibrous masses.

- Further examination is then conducted with the Polarized Light Microscope.

- The technique for identification consists of the use of the oil immersion method using Cargille Laboratories, Inc, NJ 07009, *certified* refractive index liquids, Series – A, $n_D^{25°C}$ 1.400 to 1.800; or a similar high-end refractive index liquid.

- Analysis is with a Nikon Optiphot-2 Pol, Polarizing Light Microscope, 40x to 1000x magnification, with digital imagery capability; or similar high-end instrument.

- The specific reference texts to be relied upon are:

  Amphiboles: Crystal Chemistry, Occurrence, and Health Issues, Reviews in Mineralogy and Geochemistry, Volume 67, Mineralogical Society of America, 2007, Chantilly, VA, 545 p., ISBN number 978-0-939950-79-9.

  An Introduction to the Rock-Forming Minerals, Second Edition, W.A. Deer, R.A. Howie, J. Zussman, Prentice Hall an Imprint of Pearson Education Limited, Edinburgh Gate, Harlow, Essex, CM 20 2JE England, 1992, 696 p., ISBN number 0-582-30094-0.

  Optical Crystallography, F. Donald Bloss, Mineralogical Society of America, Monograph Series, Publication #5, 1999, Washington, D.C., 239 p., ISBN number 0-939950-49-9.

  Optical Mineralogy, The Non Opaque Minerals, Wm. Revell Phillips, Dana T. Griffen, W.H. Freeman and Company, San Francisco, 1981, 677 p., ISBN number 0-7167-1129-X.

Selected Silicate Minerals and Their Asbestiform Varieties, Mineralogical Definitions and Identification-Characterization, W.J. Campbell, R.L.Blake, L.L. Brown, E.E. Cather, J.J. Sjoberg, United States Department of the Interior, Bureau of Mines, Information Circular 8751, 1977, 56 p.

Zeolites of the World, Rudy W. Tschernich, Geoscience Press, Inc., Phoenix, AZ, 1992, 563 p., ISBN number 0-945005-07-5

If asbestiform minerals are found, a representative sample may be sent to a qualified outside laboratory for further analysis by electron microscopy to establish mineral identification. This further analysis will include a count of the protocol mineral fibers, digital images of said fibers, and estimates of the width and length dimensions.

For the purposes of this Identification Guide, "qualified" means accredited by the American Industrial Hygiene Association and/or the NIST National Voluntary Laboratory Accreditation Program for asbestos analysis. The qualified laboratory must have mineralogical expertise and have the ability and experience to detect protocol mineral fibers in the natural environment (e.g., rocks, soils, etc.) as per the NIST definition contained in the Glossary.

In a case where any sample contains any serpentine group minerals, these samples will be automatically forwarded to a qualified outside laboratory for Transmission Electron Microscopy (TEM) analysis to determine the presence or absence of the asbestiform habit of chrysotile.

GLOSSARY

actinolite - A bright-green or grayish-green monoclinic mineral of the amphibole group with the general formula: $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$. The specific chemical compositions for which the name actinolite formally applies are given by Leake et al., 1997. It sometimes occurs in the form of asbestos, and also in fibrous, radiated, or columnar forms in metamorphic rocks (such as schists) and in altered igneous rocks.

aggregate - (a) A mass or body of rock particles, mineral grains, or a mixture of both. (b) Any of several hard, inert materials, such as sand, gravel, slag, or crushed stone, used for mixing with a cementing or bituminous material to form concrete, mortar, or plaster; or used alone, as in railroad ballast or graded fill. The term sometimes includes rock material used as chemical or metallurgical fluxstone, or filtration medium.

amosite - A commercial term for an iron-rich, asbestiform variety of amphibole occurring in long fibers.

amphibole - A group of dark rock-forming ferromagnesian silicate minerals, closely related in crystal form and composition and having the general formula: $A_{2\text{-}3}B_5(Si,Al)_8O_{22}(OH)_2$, where A = MG, Fe^{2+}, Ca, or Na, and B = Mg, Fe^{2+}, Fe^{3+}, Li, Mn or Al. It is characterized by a cross-linked double chain of tetrahedra with a silicon:oxygen ratio of 4:11, by columnar or fibrous prismatic crystals, and by good prismatic cleavage in two directions parallel to the crystal faces and intersecting at angles of about 56° and 124°; colors range from white to black. Most amphiboles crystallize in the monoclinic system, some in the orthorhombic. They constitute an abundant and widely distributed constituent in igneous and metamorphic rocks (some are wholly metamorphic), and they are analogous in chemical composition to the pyroxenes.

anthophyllite - A clove-brown to colorless orthorhombic mineral of the *amphibole* group with an ideal formula of: $(Mg,Fe^{2+})_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$. Variations in composition permitted under the name anthophyllite are specified by Leake et al, 1997. Anthophyllite occurs in metamorphosed ultrabasic rocks, typically with olivine or talc. It may be found in monomineralic aggregates of parallel or radiating asbestiform fibers. It has been mined for asbestos.

asbestos - A commercial term applied to a group of silicate minerals that readily separate into thin, strong fibers that are flexible, heat resistant, and chemically inert, and therefore are suitable for uses (as in yarn, cloth, paper, paint, brake linings, tiles, insulation, cement, fillers, and filters) where incombustible, nonconducting, or chemically resistant material is required. According to the National Institute of Standards and Technology (NIST), Certificate of Analysis, Standard Reference Material® 1867a, Uncommon Commercial Asbestos, "asbestos minerals possess (certain) properties such as long fiber length and high tensile strength. Under the light microscope . . . samples exhibit the asbestiform habit as defined by several of the following characteristics: 1) mean aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 μm, 2) very thin fibrils, usually less than 0.5 μm in width, 3) parallel fibers occurring in bundles, 4) fiber bundles displaying splayed ends, 5) fibers in the form of thin needles, 6) matted masses of individual fibers, and 7) fibers showing curvature."

asbestiform - A technical term which refers to a mineral habit where mineral crystals grow in a single dimension, until they form long, thread-like fibers with aspect ratios ranging from 20:1 to 100:1 or higher for fibers longer than 5 microns; very thin fibrils, usually less than 0.5 microns in width; parallel fibers occurring in bundles; and one or more of the following: fiber bundles displaying splayed ends, matted masses of individual fibers, or fibers showing curvature.

chrysotile - A white, gray, or greenish orthorhombic or monoclinic mineral of the serpentine group: $Mg_3Si_2O_5(OH)_4$. Chrysotile is a highly fibrous, silky variety of serpentine, and constitutes what was historically the type of asbestos most commonly used.

cleavage fragment - A fragment of a crystal that is bounded by cleavage faces, formed by physical separation from a larger crystal. The dimensions of a cleavage fragment are defined by the orientation of the weakest cleavage planes in the parental crystal.

crocidolite - A lavender-blue, indigo-blue, or leek-green asbestiform variety of the amphibole riebeckite, occurring in silky fibers and in massive and earthy forms.

erionite - A white, relatively common sedimentary zelolite, is found in either acicular or fibrous habitats, having the general formula: $Na_8[(AlO_2)_8(SiO_2)_{40}]$.

fiber - Commonly, a slender, elongated, threadlike object or structure. In regulatory and biomedical literature, "fiber" has been used many different ways, and has no specific, stand-alone meaning. Generally, "fiber" is a relative term that has come to mean any elongated particle that satisfies specific dimensional constraints. Dimensional constraints placed on the definition of the term "fiber" are specific to the particular analytical method/exposure metric by which fiber concentrations are determined for a particular application. In contrast to other terms such as "asbestiform," "fiber" is not linked to a specific list of mineralogical properties which give it a consistent meaning across analytical methods and/or exposure metrics.

fibrous - A relative term that is used to denote a material composed primarily of fibers or one that appears to be composed of fibers.

greenfield - Land from which aggregate materials have not previously been mined.

habit - The characteristic crystal form or combination of forms of a mineral, including characteristic irregularities; the way a mineral grows.

igneous - Said of a rock or mineral that solidified from molten or partly molten material, i.e. from a magma or lava; also, applied to processes leading to, related to, or resulting from the formation of such rocks. Igneous rocks constitute one of three main classes into which rocks are divided the others being metamorphic and sedimentary.

metamorphic - Pertaining to the process of rock transformation by heat, pressure, and/or hydrothermal solutions, referred to as metamorphism, or to its results.

muck pile - Broken material left over after a tunnel has been bored, or a surface area has been affected by drilling or blasting

NIST - National Institute of Standards and Technology.

non-asbestiform - not asbestiform in habit.

overburden - Term used to describe rock and/or soil which lies above an economically valuable material (ore) that contains material intended to be used in end product. Overburden is distinct from tailings, the material that remains after economically valuable components have been extracted from processed ore.

peer-reviewed - The process of subjecting scholarly work, research, or ideas to the scrutiny of others who are experts in the same field. Generally refers to the process used to screen manuscripts and funding applications.

PLM - Polarized Light Microscopy.

prismatic - Term for a mineral habit applied to a long, narrow, wedge-shaped body.

protocol mineral fiber - Defined in the Introduction to this document. As used herein, the term includes chrysotile, actinolite asbestos, crocidolite, amosite, anthophyllite asbestos, and tremolite asbestos, as well as all asbestiform amphiboles and all durable asbestiform zeolites. Durable asbestiform zeolites include, but are not limited to, erionite and mordenite.

reserve - Portion of quarry or sand and gravel deposit which can economically be mined given the then-existing state of mining practices and related technology.

serpentine - A group of common rock-forming minerals having the general formula: $(Mg,Al,Fe,Mn,Ni,Zn)_{2-3}(Si,Al,Fe)_2O_5(OH)_4$. Serpentines have a greasy or silky luster, a slightly soapy feel, and a tough, conchoidal fracture; they are usually compact but may be granular or fibrous, and are commonly green, greenish-yellow, or greenish-gray and often veined or spotted with green and white. Serpentines are always secondary minerals, derived by alteration of magnesium-rich silicate minerals (esp. olivines), and are found in metamorphic rocks; they generally crystallize in the monoclinic system. Translucent varieties are used for ornamental and decorative purposes, often as a substitute for jade. The minerals in the serpentine group include antigorite, lizardite, and chrysotile.

TEM - Transmission Electron Microscopy.

tremolite - A white to dark-gray monoclinic mineral of the amphibole group with an ideal formula: $Ca_2Mg_5Si_8O_{22}(OH)_2$. The specific chemical compositions to which the name tremolite formally applies are given by Leake et al., 1997. It has varying amounts of iron, and may contain manganese and chromium. Tremolite occurs in long blade-shaped or short stout prismatic crystals and also in columnar, fibrous, or granular masses or compact aggregates,

generally in metamorphic rocks such as crystalline dolomitic limestones and talc schists. It is a constituent in much commercial talc. Under some conditions, it may form asbestos.

ultramafic - Said of a rock composed chiefly of mafic minerals, e.g. monomineralic rocks composed of hypersthene, augite, or olivine, and are rich in iron and magnesium. Ultramafic rocks do not contain quartz.

zeolites - A generic term for a large group of white or colorless (sometimes tinted red or yellow by impurities) hydrous aluminosilicate minerals that have an open framework structure of interconnected $(Si,Al)O_4$ tetrahedra with exchangeable cations and H_2O molecules in structural cavities. Zeolites have long been known to occur as well-formed crystals in cavities in basalt and as authigenic minerals in the sediments of saline lakes and the deep sea and especially in beds of altered tuff. They form during and after burial, generally by reaction of pore waters with solid aluminosilicate materials (e.g., volcanic glass, feldspar, biogenic silica, and clay minerals).

SUGGESTED RESOURCES

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